

# REPORT DOCUMENTATION PAGE

Form Approved  
OMB No. 0704-0188

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1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE October 2004	3. REPORT TYPE AND DATES COVERED Technical Report	
4. TITLE AND SUBTITLE On-the move nutrient Delivery System - Description and Initial Evaluation			5. FUNDING NUMBERS	
6. AUTHOR(S) Scott J. Montain, William J. Tharion, Reed W. Hoyt				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Military Nutrition Division U.S Army Research Institute of Environmental Medicine Kansas Street Natick, MA 01760-5007			8. PERFORMING ORGANIZATION REPORT NUMBER T05-02	
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Army Medical Research and Materiel Command Ft. Detrick Federick, MD 21702-5012			10. SPONSORING / MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES				
12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release. Distribution is unlimited.			12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words) Warfighters typically under-eat relative to their energy expenditure during field training and deployments. Maintaining hydration is also a challenge, particularly during hot weather, as there is aversion to the smell and taste of warm water, particularly when chlorine is present. A novel nutrient delivery system has been developed to provide Warfighters on-demand access to flavored electrolyte- and carbohydrate-enhanced drinks, to provide hydration, and energy to sustain work. This technical report documents efforts to obtain user feedback regarding the acceptability of an early prototype system. The combined results of two different survey groups (n= 22) reveal that 59% of Soldiers rated the device as a "moderately" to "extremely valuable" and 68% reported that they would be "moderately" to "extremely likely" to use the device if it were available to them. 73% felt it could improve their performance. Recommended improvements included making hardware components more rugged, improving engineering to minimize leakage, adding more positive control of the on-off system, and creating a variety of flavored beverages with high taste acceptability.				
14. SUBJECT TERMS			15. NUMBER OF PAGES 30	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT UNCLASSIFIED	18. SECURITY CLASSIFICATION OF THIS PAGE UNCLASSIFIED	19. SECURITY CLASSIFICATION OF ABSTRACT UNCLASSIFIED	20. LIMITATION OF ABSTRACT UL	



**TECHNICAL REPORT 05-02**

**ON-THE-MOVE NUTRIENT DELIVERY SYSTEM—  
DESCRIPTION AND INITIAL EVALUATION**

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October 2004

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Human subjects participated in these studies after giving their free and informed voluntary consent. Investigators adhered to AR 70-25 and USAMRMC Regulation 70-25 on the use of volunteers in research.

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## **ACKNOWLEDGEMENTS**

The authors wish to acknowledge and thank Matthew Kressy, Designturn, Inc., Natick, MA, and Steve Wolfson, Medicept, Inc., Ashland, MA, for their work designing and manufacturing the prototype On-the-Move Nutrient Delivery System used in this evaluation. We also thank Danielle Anderson and Betty Davis, Combat Feeding Program, Natick Soldier Center, RDECOM, for their work in formulation and packaging of the beverage concentrate; Matthew Kressy and Chris Palmer, Navy Special Operations Command, for their assistance with the data collection; CPT Patrick Gaffney, 509<sup>th</sup> Parachute Infantry Battalion, Ft. Polk, LA, for his professionalism and invaluable assistance coordinating the JRTC testing; and lastly, the volunteers who participated in this investigation.

## EXECUTIVE SUMMARY

Warfighters typically under-eat relative to their energy expenditure during field training and deployments. Maintaining hydration is also a challenge, particularly during hot weather, as there is aversion to the smell and taste of warm water, particularly when chlorine is present. A novel nutrient delivery system has been developed to provide Warfighters on-demand access to flavored electrolyte- and carbohydrate-enhanced drinks, and to provide hydration and energy to sustain work. This technical report documents efforts to obtain user feedback regarding the acceptability of an early prototype system. The combined results of two different survey groups (n=22) reveal that 59% of Soldiers rated the device as "moderately valuable" to "extremely valuable" and 68% reported that they would be "moderately likely" to "extremely likely" to use the device if it were available to them. 73% felt it could improve their performance. Recommended improvements included making hardware components more rugged, improving engineering to minimize leakage, adding more positive control of the on-off system, and creating a variety of flavored beverages with high taste acceptability.



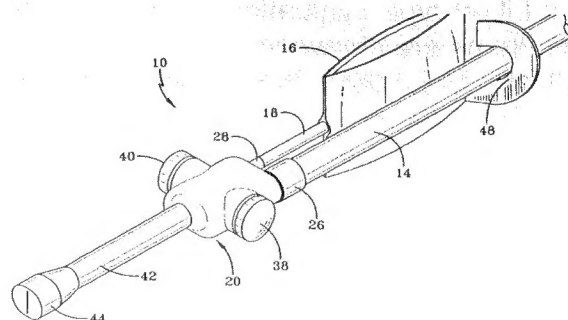
## INTRODUCTION

Delivery of adequate water, electrolytes, and nutrients to sustain Warfighter performance during prolonged work in hot climates and/or work in personal protective equipment will be essential for mission success. Obstacles to sustaining Warfighter hydration and nutritional status include the following: (1) chlorinated/iodinated water has an unacceptable taste, thereby discouraging voluntary intake; (2) the addition of flavorings to chlorinated water almost instantly compromises resistance to contamination; (3) limited ration intake during field training generally results in inadequate electrolyte and carbohydrate consumption; (4) the addition of sodium to water without flavoring accentuates the unpleasant taste of chlorine; (5) the addition of carbohydrate to the water supply increases the risk of mold and bacterial growth inside personal bladder-type water delivery systems; and (6) bacterial contamination of the water supply can produce diarrhea.

The On-the-Move Nutrient Delivery System (OMNDS) (Figure 1) was designed to overcome many of the obstacles to maintaining proper hydration (3). It integrates with typical commercially available collapsible bladder-type canteen systems in which water is consumed through a drinking tube. The OMNDS consists of (a) a regulator for selecting water or mixed beverage, (b) a bag of juice concentrate, and (c) a small feeder line between juice concentrate bag and regulator. The advantages of the OMNDS over existing technologies are that OMNDS does not require a separate drink container (e.g., canteen cup) to mix drink ingredients; there is no requirement for the user to physically add water to powder or vice versa before consumption (e.g., adding beverage base to canteen); and the OMNDS does not contaminate the water reservoir or compromise water resistance to contamination.

This technical report summarizes user feedback regarding the utility and functionality of first-generation OMNDS prototypes. We report results of initial taste testing of non-caloric flavored electrolyte formulations, and the results of three separate evaluations by Warfighters regarding the acceptability of the OMNDS for field use, overall design, and capabilities.

Figure 1. Drawing of the On-the-Move Nutrient Delivery System. Regulator (#20) controls flow from water reservoir feed line (#14) and from beverage concentrate feed line (#18) and beverage bag (#16).



## EVALUATION OF ELECTROLYTE BEVERAGE FORMULATIONS

### METHODS

9 volunteers (6 men, 3 women), (2, 25-29 yr; 5, 30-34 yr; 2, 35-39 yr) participated in a taste-test evaluation of three formulations (identified as K, Q, and S3) of a lemon-flavored electrolyte beverage concentrate developed by the U.S. Army Combat Feeding Program (Natick Soldier Center, Natick, MA) food engineers. When diluted 1:40, each drink contained approximately 25 mEq/L sodium, 29 mEq/L chloride, and 4 mEq/L potassium. The three formulations differed in the amount of flavor and sucralose, with formulation K having the lowest, and formulation S3 the highest concentrations (Table 1). Citric acid, sodium citrate, and potassium sorbate were included as preservatives. The electrolyte beverage formulations were provided in concentrate form and were diluted to 1:40 with water to make them equivalent to the dilution produced by the OMNDS. The purpose of this evaluation was to provide data for down selection to the most preferred formulation and to ensure that the chosen formulation was acceptable for use.

Volunteers consumed the three electrolyte beverages before and after their regularly scheduled mid-day voluntary exercise routines (duration: 30 and 60 min). Exercise routines consisted of running, weight training, and the use of cardiovascular equipment. Each volunteer consumed approximately 50 ml of a beverage formulation and then completed a 6-item, 9-point Likert-type evaluation form (items are shown in

Table 1. Electrolyte beverage formulations.

Ingredients	Least sweet	Sweetest	
	K	Q	S3
	Grams**	Grams**	Grams**
Citric acid	2.81	3.22	3.41
Lemon flavor DY03014 Quest	3.36	3.89	4.08
Sucralose (dry)	2.88	13.56	12.00
Sucralose (liquid)	0.00	0.00	0.48
Sodium citrate	0.24	0.36	0.41
NaCl	5.76	5.76	5.76
KCl	1.20	1.20	1.20
Water	86.93	79.44	78.70
Potassium sorbate	0.12	0.12	0.12
Approximate densities (g/ml)	1.07	1.12	1.10

\*\*Formulas make up 100 ml, not 100 grams.

Table 1). Volunteers then consumed approximately 50 ml of water after swishing it around in their mouth, before consuming the next beverage. After consuming the next beverage, they completed the questionnaire and, again, rinsed their mouth with water. This process was continued until all three test beverages were evaluated before and after exercise. Consumption order of beverages was balanced across volunteers and test sessions. The order of beverage consumption was randomized among volunteers.

Two-factor (beverage type [K, Q, and S3] by exercise state [pre and post]) repeated measures analysis of variance (ANOVA) was performed on each of the 6 items. There were no main effects of exercise condition, nor were there any interaction effects. Main effects existed by beverage type for all items except for beverage texture (Table 2). Values greater than 5.0 indicated a beverage received favorable ratings.

## RESULTS

Electrolyte beverages Q and S3 ratings did not differ statistically, and both received positive ratings on all test items surveyed. Electrolyte beverage K was rated unfavorably on all items except for texture. All beverages tended to be rated higher after exercising on all test items, but these differences were not significantly different. The most common negative comment was that electrolyte beverage K was too salty. The most common positive comment was that electrolyte beverage S3 had a good amount of sweetness. No volunteer considered any beverage as too sweet. Some volunteers thought that electrolyte beverage K was too bland. While electrolyte beverages Q and S3 did not differ statistically, there was an overall pattern of S3 receiving higher ratings than beverage Q. Therefore, the data show that electrolyte beverage S3 was the preferred beverage.

Table 2. Ratings of flavored electrolyte beverage characteristics obtained before and after physical exercise.

Test Characteristic	Electrolyte Beverage K	Electrolyte Beverage Q	Electrolyte Beverage S3	Main Effect Significance Between Beverages
<sup>1</sup> Sweetness Pre-Exercise Post-Exercise	$3.1 \pm 1.5^a$ $3.4 \pm 1.0$	$5.3 \pm 1.7^b$ $5.8 \pm 1.9$	$6.1 \pm 1.4^b$ $7.0 \pm 0.7$	0.001
<sup>1</sup> Texture Pre-Exercise Post-Exercise	$5.6 \pm 1.9$ $5.6 \pm 1.7$	$6.1 \pm 1.8$ $6.7 \pm 1.4$	$6.4 \pm 1.1$ $7.0 \pm 1.0$	Not Significant
<sup>1</sup> Flavor Pre-Exercise Post-Exercise	$3.8 \pm 1.4^a$ $3.9 \pm 1.5$	$5.6 \pm 1.3^b$ $5.9 \pm 1.5$	$6.4 \pm 1.4^b$ $7.1 \pm 0.3$	0.001
<sup>1</sup> Overall Rating Pre-Exercise Post-Exercise	$3.6 \pm 1.4^a$ $4.0 \pm 1.5$	$5.6 \pm 1.4^b$ $5.9 \pm 1.8$	$6.7 \pm 1.1^b$ $7.1 \pm 0.3$	0.001
<sup>2</sup> Viewed as Valuable Supplement Pre-Exercise Post-Exercise	$4.4 \pm 2.1^a$ $4.4 \pm 1.7$	$6.2 \pm 1.3^b$ $6.6 \pm 1.6$	$6.7 \pm 1.3^b$ $7.4 \pm 0.5$	0.001
<sup>2</sup> Would Likely Consume as a Supplement Pre-Exercise Post-Exercise	$3.9 \pm 1.5^a$ $4.4 \pm 1.9$	$6.2 \pm 1.2^b$ $6.4 \pm 1.6$	$6.7 \pm 1.6^b$ $7.6 \pm 0.7$	0.001

\*Values are Means  $\pm$  Standard Deviations.

\*\*Superscript letters a and b designate significant differences between beverages using Post Hoc Least Significant Difference Paired Comparison Tests.

Score Anchor Words: <sup>1</sup> 1 = Dislike Extremely, 2 = Dislike Very Much, 3 = Dislike Moderately, 4 = Dislike Slightly, 5 = Neither Like nor Dislike, 6 = Like Slightly, 7 = Like Moderately, 8 = Like Very Much, 9 = Like Extremely

Score Anchor Words: <sup>2</sup> 1 = Extremely Unlikely, 2 = Very Unlikely, 3 = Moderately Unlikely, 4 = Somewhat Unlikely, 5 = Neither Likely nor Unlikely, 6 = Somewhat Likely, 7 = Moderately Likely, 8 = Very Likely, 9 = Extremely Likely

## **SOLDIER FEEDBACK REGARDING ACCEPTABILITY OF FIRST-GENERATION OMNDS**

The OMNDS prototype used for Soldier feedback is illustrated in Figure 2. The regulator was machined plastic with embedded inlet water and juice channels, with different internal diameters, a y-connection, and single outlet channel. A push-button system controlling flow through each inlet channel enabled the user to control flow from either water or beverage concentrate reservoir separately, or to draw liquid from each reservoir simultaneously (producing a mixed drink). Backflow into the water reservoir was prevented by a one-way valve. To use the system, the user attached a beverage concentrate pouch onto the extension line by puncture of a sharpened plastic tip thru a plastic membrane; the pouch was held to the extension line connector by friction. The user then pushed the water button and/or juice buttons in to enable liquid to flow from the reservoirs when the user sipped on the bite valve. If both buttons were in the "on" position and the user sipped from the system, the water and beverage concentrate mixed in the regulator enroute to the bite valve, creating a properly diluted, mixed drink. To turn the system off, the user pushed the buttons back to the closed position.

Two beverage concentrate formulations were evaluated; the flavored electrolyte beverage (S3 from the flavored electrolyte beverage tests), and a carbohydrate-electrolyte drink (29 g lemon lime Gatorade® powder, 33 g Isosweet® 100, 0.1 g sodium benzoate, 0.05 g NaCl, 0.1 g KCl, 57.5 g water).

### **EVALUATION 1: JOINT READINESS TRAINING CENTER MILITARY READINESS EXERCISE**

#### **Methods**

Volunteers were 17 male Soldiers (5, 19-24 yr; 11, 25-29 yr; 1, 30-34 yr) of the 1<sup>st</sup> Battalion (Airborne) 509<sup>th</sup> Infantry participating as the Opposition Force (OPFOR) during a 2-week Military Readiness Exercise (MRX) at the Joint Readiness Training Center (JRTC), Ft. Polk, LA; where they performed simulated terrorist activities in a simulated Iraqi location. The MRX consisted mostly of low intensity activity in an urban environment, although there were brief time periods (up to 30 min) of more intense physical activities (e.g., running, climbing, firing weapons).

Figure 2. On-the-Move Nutrient Delivery System (OMNDS) prototype used for evaluation. In use, the beverage concentrate resided in pocket on backpack.



Soldiers were informed of the purpose and methodology of this assessment during a break in the MRX prior to evaluating OMNDS. Volunteers were told we were seeking input on the acceptability and utility of the OMNDS, as well as product feedback on the device itself, the product packaging, and acceptability of a lemon-flavored, electrolyte-containing drink. They were shown how to connect the electrolyte beverage bag to the OMNDS connector hose, as well as how to use the two control buttons to obtain water only, electrolyte concentrate only, or a mixture of the two, from the collapsible-bladder hydration system (Camelbak, San Diego, CA). Volunteers were told that the electrolyte beverage in the single packet would make about 2 liters of a lemon-flavored drink. They were instructed to fill their bladder canteens completely full prior to the start of the evaluation.

Volunteers were told that developers thought this device might be useful for the following reasons: (1) research has shown that people will drink more if their drinks are flavored; (2) research has shown that people involved in long endurance tasks benefit from supplemental electrolytes, as well as carbohydrate; (3) the device creates a flavored mixed drink in an automated manner; no stirring or manual mixing is required; (4) the OMNDS keeps the water reservoir clean; and (5) the user can select the beverage they want, when they want it, and in the quantity they want. They were informed that in this test, there was no carbohydrate in their juice concentrate--just electrolytes and juice flavoring.

Volunteers were instructed to use the OMNDS for 2-3 hr (or longer) as they performed their duties, and to complete a 19-item questionnaire (Appendix 1) as soon as possible after testing the OMNDS. They were also instructed to provide comments (positive or negative) so that the developers of the system could understand what they liked or disliked about the OMNDS. Five OMNDS were used in this evaluation.

## **Results**

The questionnaire results are summarized in Table 3. Written comments are summarized in the table legend. Figures 3-6 illustrate the distribution of responses to specific questions.

Table 3. Responses from 17 Soldiers who used the OMNDS during Joint Readiness Training Center Military Readiness Exercise. Except where indicated, the questions utilized a 9-point scale, with the higher number being more acceptable. Anchor words for the 9-point scale are shown in Figures 2-5.

Question	Mean	Median	N
Would the OMNDS be a valuable device for field use? <sup>1</sup>	6.1	7	17
Would you use this item if it were available for your use?	6.6	7	17
How likely would you use the OMNDS during Garrison training?	5.4	5	17
How likely would you use OMNDS when field kitchen is available?	5.0	6	17
How likely would you use OMNDS when relying on MRE?	6.1	7	17
How likely would you use OMNDS during cold weather operations?	5.8	6	17
How likely would you use OMNDS during hot weather operations?	6.7	7	17
Overall, how much do you like or dislike the OMNDS?	6.4	7	17
Level of ease attaching the drink concentrate bag to the OMNDS	6.8	8	17
Ease of selecting/switching between receiving water only and receiving the beverage	6.8	8	17
Overall acceptability for attaching the drink concentrate bag onto the drinking tube and OMNDS <sup>2</sup>	6.0	5	17
Acceptability of Regulator size (5-point scale)	3.3	3	17
Acceptability of Regulator weight (5-point scale)	3.1	3	17
Preference for portion size <sup>3</sup>	5.0	5	17
Rating of aspects of flavored beverage <sup>4</sup>			
▪ Flavor	4.4	4	17
▪ Sweetness	4.4	5	17
▪ Texture	4.6	5	17
▪ Overall	4.9	5	17

<sup>1</sup> Comments were that it would be helpful for sustaining hydration and performance, and that it was easy to use (e.g., "the idea is great, very practical," "I would use product!"). Concerns were that the system wasn't sturdy enough, there were leaks from the back of the buttons, the hose connection needed improvement, and the flavor could be improved.

<sup>2</sup> 7 of 17 Soldiers reported system leaks. Comments suggested leaks occurred at valve and bag connection. Suggested improvements included inserting both hoses inside same insulated sleeve, covering buttons, using tactical colors, securing concentrate bag inside main bladder pouch, and adding more hose length. The button valves were also rated as being too soft, and the flat-sided surface was not durable enough.

<sup>3</sup> 65% preferred a soft package over a hard package.

<sup>4</sup> Variety of flavors desired. Flavors most frequently mentioned included cherry, orange, and grape. Shake formulations were also suggested. Low scores may be artificially low, as it appeared from the comments section that several participants rated the taste of the beverage concentrate in concentrated form rather than the diluted drink.

## EVALUATION 2: 20-MILE ROAD MARCH

### Methods

5 Soldiers of the 1<sup>st</sup> Battalion (Airborne) 509<sup>th</sup> Infantry, Ft. Polk, LA, evaluated the system during a unit 20-mile road march. The same questionnaire was used as during Evaluation #1 (described above), and the drink evaluated was the electrolyte beverage (formulation S3). Three of the volunteers were 19-24 yrs, one was 25-29 yrs,



and the other was 40-44 yrs of age. Each Soldier was provided an OMNDS and one electrolyte beverage packet.

## Results

The results of this survey are summarized in Table 4. The written responses are summarized in the legend of the table. The ratings of the OMNDS were similar to those obtained in Evaluation 1. Frequency distribution of responses are illustrated in Figures 3-6.

Table 4. Responses from 5 Soldiers who used the OMNDS during the 20-mile road march. Except where indicated, the questions utilized a 9-point scale, with the higher number being more acceptable.

Question	Median	Mean	Range
Would the OMNDS be a valuable device for field use? <sup>1</sup>	7	6.2	3-8
Would you use this item if it were available for your use?	7	6.2	3-9
How likely would you use the OMNDS during Garrison training? <sup>2</sup>	3	4	2-9
How likely would you use OMNDS when field kitchen is available?	4	5.2	3-9
How likely would you use OMNDS when relying on MRE?	6	5.8	3-9
How likely would you use OMNDS during cold weather operations? <sup>3</sup>	5	5.2	4-6
How likely would you use OMNDS during hot weather operations?	6	6.6	5-9
Overall, how much do you like or dislike the OMNDS?	6	6	4-8
Level of ease attaching the drink concentrate bag to the OMNDS	8	7.2	5-8
Overall, how acceptable was the system for attaching the drink concentrate bag onto the drinking tube and OMNDS? <sup>4,5</sup>	7	5.4	3-7
Ease of selecting/switching between receiving water only and receiving the beverage	8	5.8	1-8
Acceptability of Regulator size (5-point scale)	3	3.2	2-5
Acceptability of Regulator weight (5-point scale)	3	3.6	3-5
Preference for portion size	6	5.6	4-7

<sup>1</sup> Useful, good hydration.

<sup>2</sup> The Soldier who rated the system low wrote that it seemed kind of pointless; "Can you just mix in water bag?"

<sup>3</sup> Package could freeze in cold weather.

<sup>4</sup> Connections and disconnections are somewhat of a hassle (n=2).

<sup>5</sup> Suggest integrating two separate tubes into single tube (n=2).

## SUMMARY OF OMNDS ACCEPTABILITY

Individual responses to the questions are illustrated in Figures 3-6. 13 of 22 (59%) JRTC Soldiers participating in the evaluation (MRX & road march groups) rated the OMNDS as "moderately valuable" to "extremely valuable" for field use. 15 of 22 (68%) reported that they would be "moderately likely" to "extremely likely" to use OMNDS if made available to them. 73% thought the device would improve their performance. The prototype version received a median score of 7 (9-point scale) for overall acceptability. The Soldiers felt the regulator size and mass were "acceptable" to "slightly too heavy" and "acceptable" to "slightly too large". 68% rated ease of switching



between water only and flavored drink at “moderately easy” to “very easy”. Major weaknesses appeared to be in the ruggedness of the button system, and leaks at the connection point between beverage pouch and connector line and also at the regulator valves. The electrolyte beverage formulation received mixed ratings (mean score 4.7; median score 5, “neither like nor dislike”). 11 of 22 Soldiers rated the flavor negatively (<5 out of 9). 8 of 22 rated sweetness unfavorably. It should be mentioned, however, that based on the written comments, Some of the beverage ratings may reflect the Soldiers rating of the flavor of the undiluted concentrate rather than the mixed beverage. The lack of overall satisfaction of the drink may have also affected their rating of the system as a whole. Regardless, the Soldiers surveyed desired a range of flavors that tasted good. Most common listed flavors were fruit flavors.

Figure 3. Frequency distribution for acceptability of OMNDS for Soldiers participating in Joint Readiness Training Center Military Readiness Exercise (light grey) or 20 mile road march (dark grey).

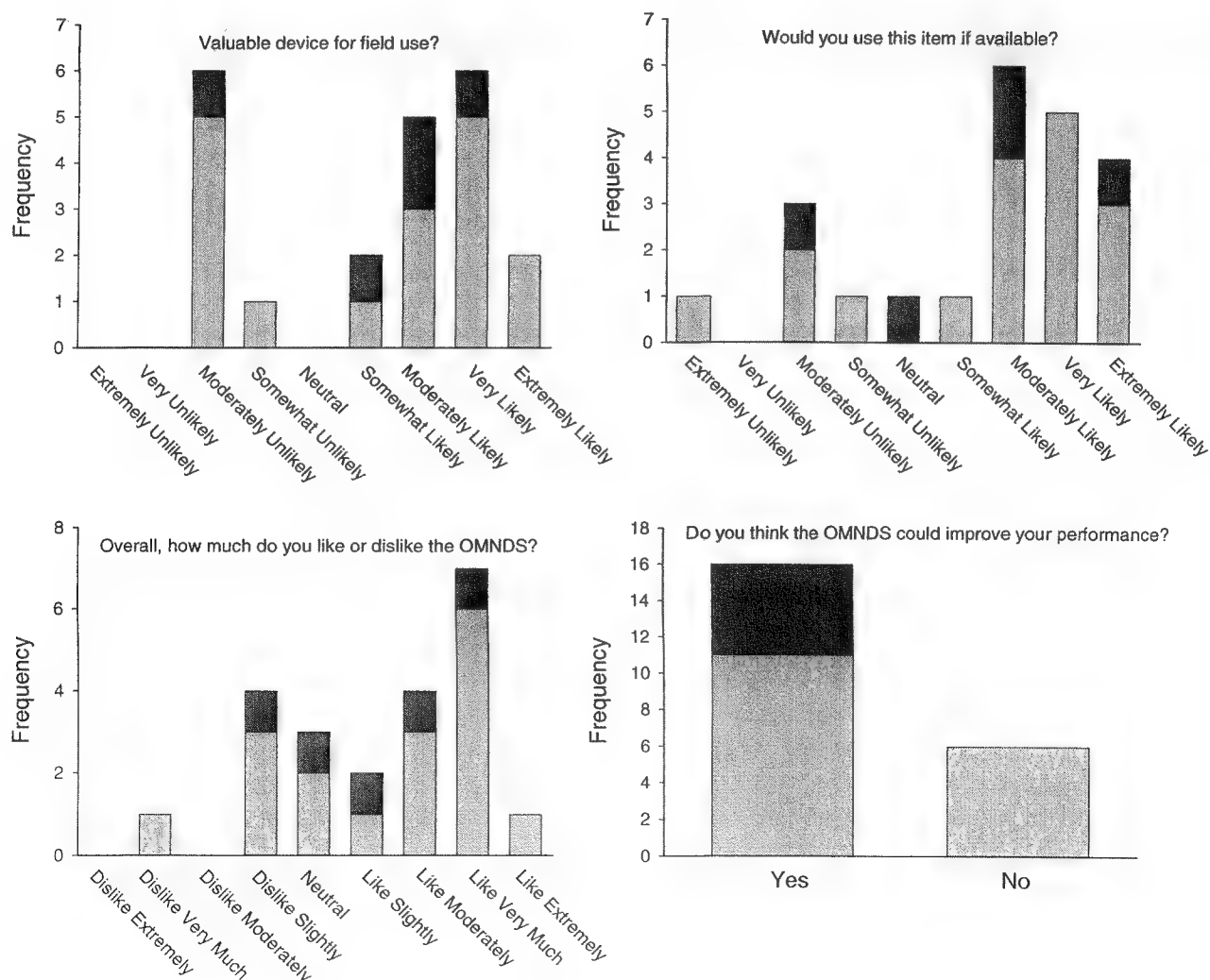


Figure 4. Frequency distribution for likelihood of using OMNDS for Soldiers participating in Joint Readiness Training Center Military Readiness Exercise (light grey) or 20 mile road march (dark grey).

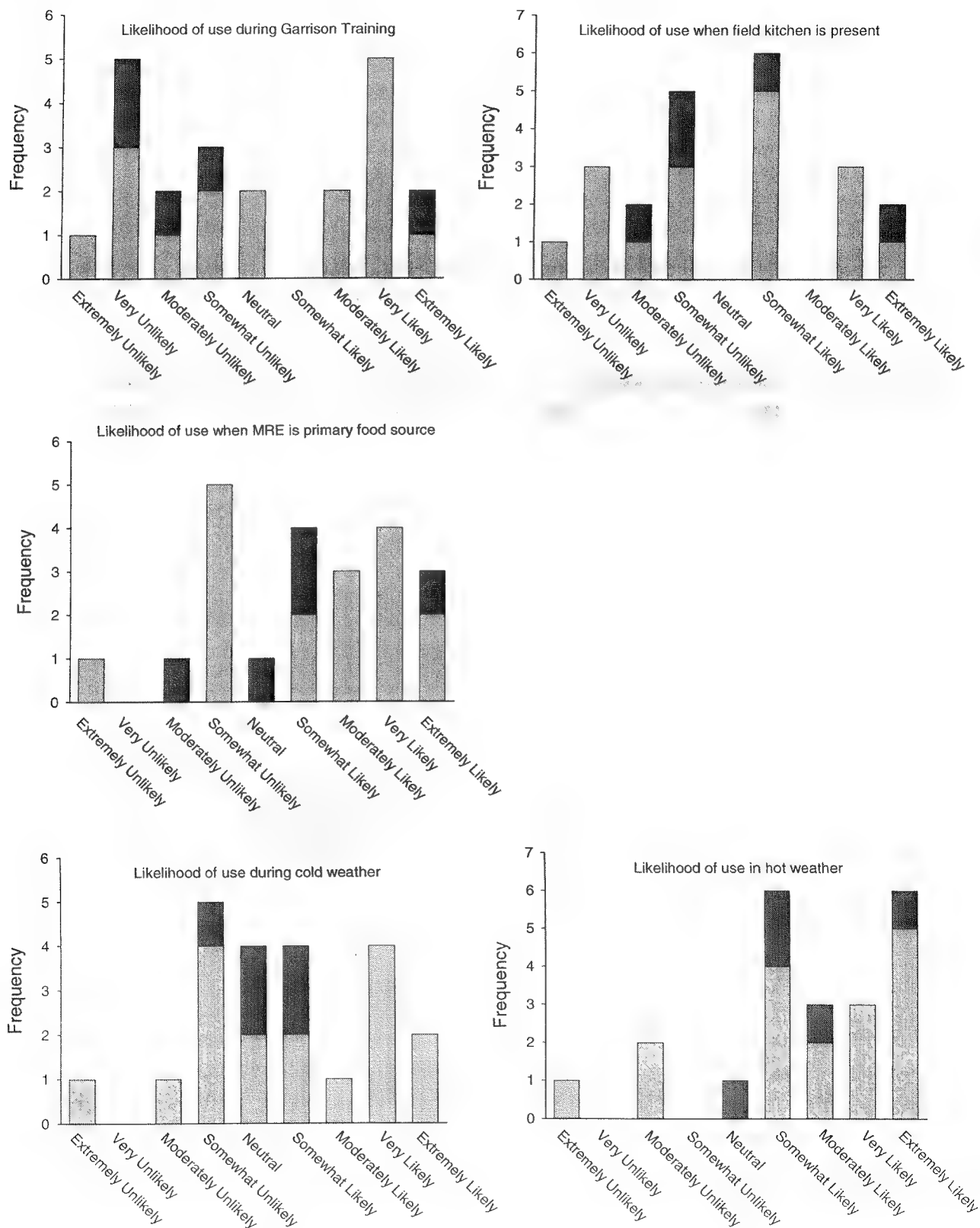


Figure 5. Frequency distribution of acceptability of OMNDS operating characteristics for Soldiers participating in Joint Readiness Training Center (light grey) or 20 mile road march (dark grey).

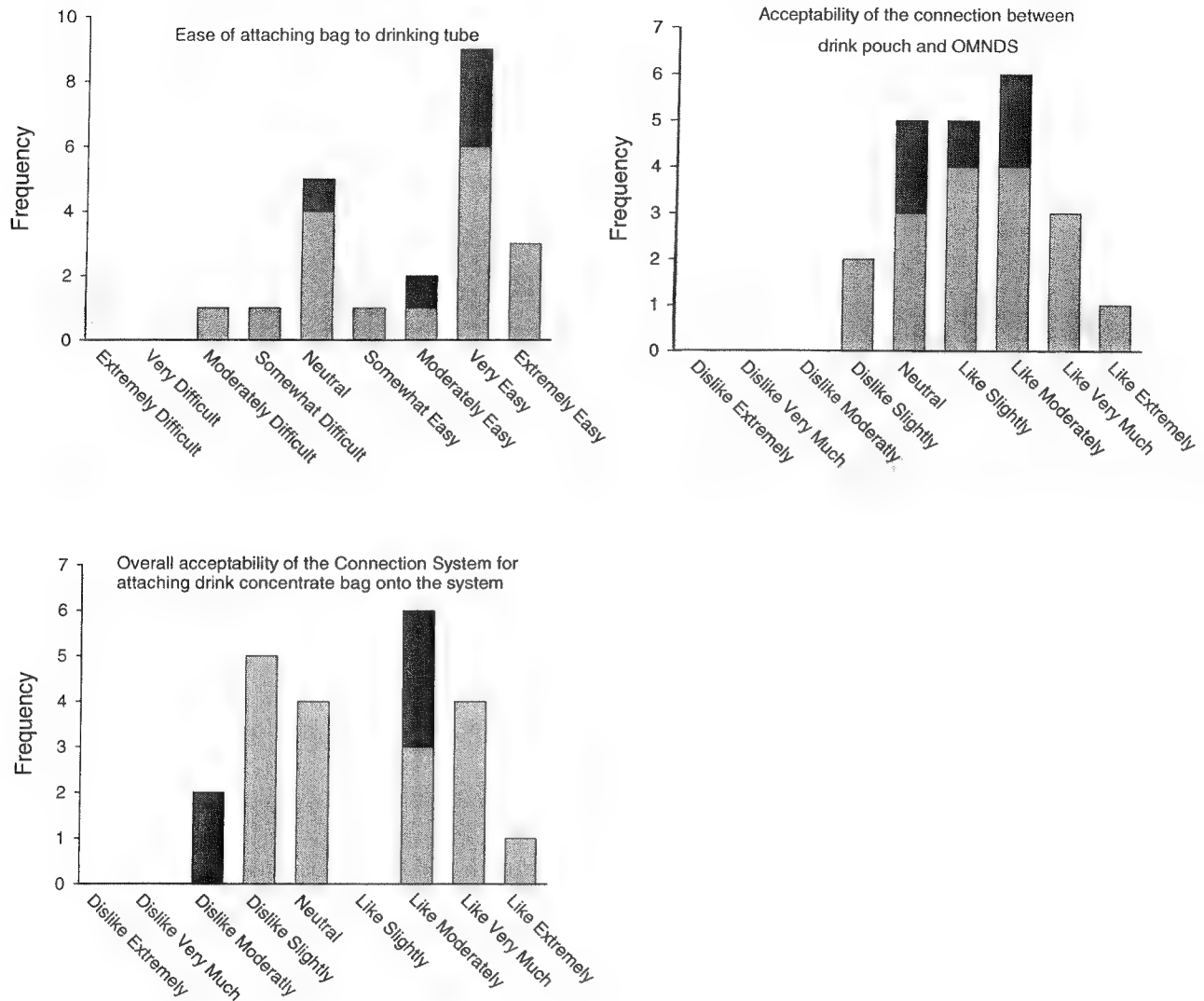
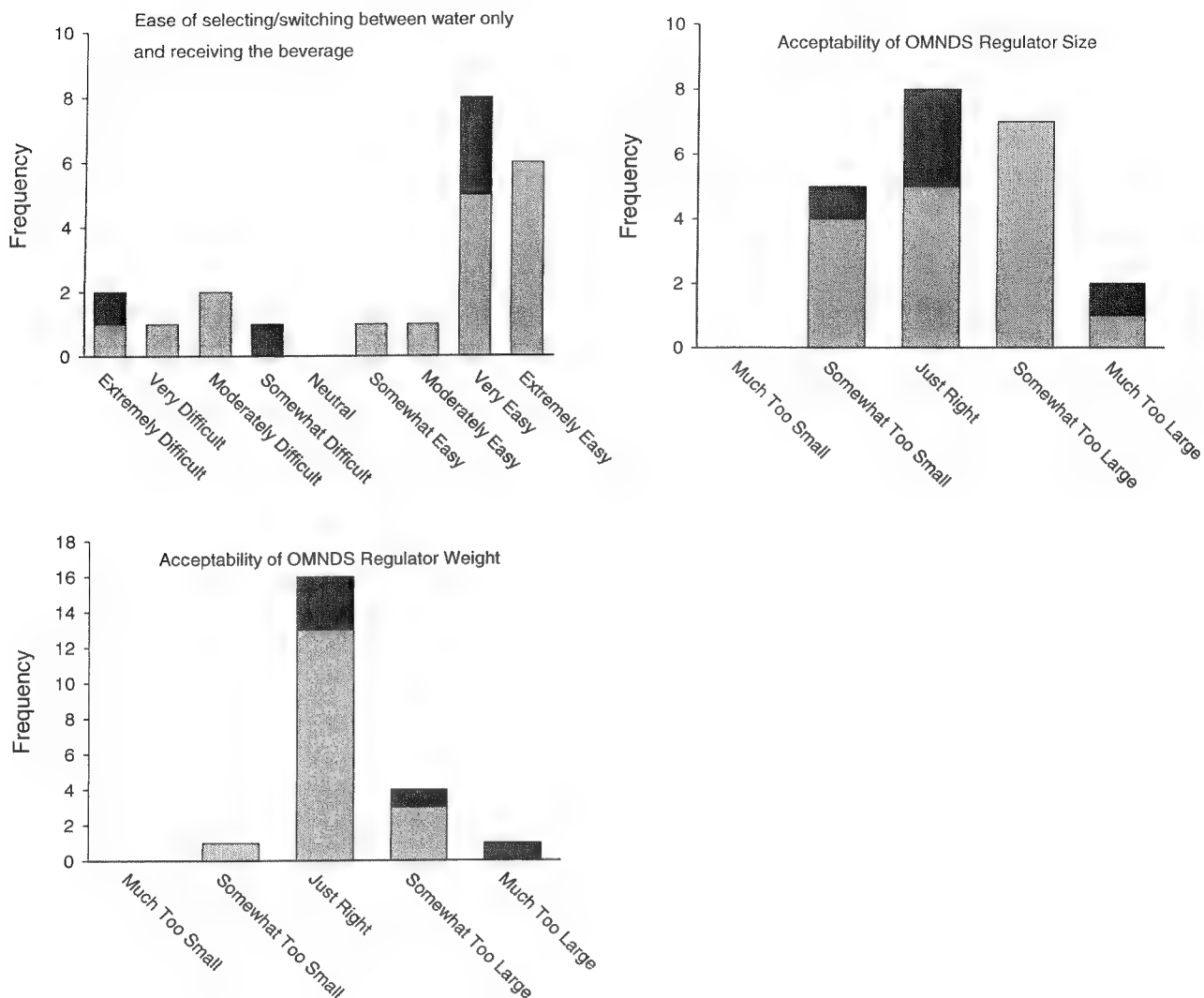


Figure 6. Frequency distribution of acceptability of OMNDS system operation and OMNDS size for Soldiers participating in Joint Readiness Training Center Military Readiness Training Exercise (light grey) or 20 mile road march (dark grey).



### EVALUATION 3: NAVY SPECIAL OPERATIONS

#### Methods

16 Sailors assigned to Navy Special Operations evaluated the system during physical training. A similar questionnaire was used as during evaluation #1 (described above), with additional questions regarding acceptability of mixing and flavor. The drink concentrate evaluated was the flavored carbohydrate-electrolyte formulation that when diluted, produced a lemon-lime drink (~5% CHO, 20 mEq/L sodium, 5 mEq/L

potassium). 5 of the volunteers were 25-29 yrs, 7 were 30-34 yrs, 3 were 35-40 yrs, and 1 was 40-44 yrs of age. 100% evaluated the device during physical activity. Data were collected by representatives of the Navy Special Operations Command. Only mean responses were provided by the Navy representatives, eliminating the possibility of combining these Warfighter's scores with the data from Ft. Polk, LA.

## Results

The results from Evaluation 3 are summarized in Table 5. This group generally rated the system somewhat lower than in OMNDS Evaluation 1 & 2, but this appeared primarily due to a concern that the system (in present form) was not rugged enough for field operations. The participants also felt the regulator should be somewhat smaller and lighter. They also recommended redesigning the on-off system with more positive control.

Table 5. Responses from 16 Navy Special Operations personnel who used the OMNDS during physical training. Except where indicated, the questions utilized a 9-point scale, with the higher number being more acceptable. Anchor words are shown in Figures 3-6.

Question	Mean	N
Would the OMNDS be a valuable device for field use? <sup>1</sup>	5.2	16
Would you use this item if it were available for your use?	5.7	16
How likely would you use the OMNDS during Garrison training?	6.3	16
How likely would you use OMNDS when field kitchen is available?	5.8	14
How likely would you use OMNDS when relying on MRE?	6.1	16
How likely would you use OMNDS during cold weather operations?	4.9	16
How likely would you use OMNDS during hot weather operations?	5.4	15
Overall, how much do you like or dislike the OMNDS?	5.7	16
Level of ease attaching the drink concentrate bag to the OMNDS	8.5	16
Overall, how acceptable was the system for attaching the drink concentrate bag onto the drinking tube and OMNDS? <sup>2</sup>	6.7	16
Ease of selecting/switching between receiving water only and receiving the beverage <sup>3</sup>	7.1	15
Acceptance of the mix of the water and concentrate in the OMNDS system	6.8	15
The beverage received was too strong (1), just right (2), or too weak (3)	1.7	16
Acceptability of Regulator size (5-point scale)	4.2	16
Acceptability of Regulator weight (5-point scale)	3.8	16
Preference for portion size <sup>4</sup>	7.6	16
Rating of aspects of flavored beverage <sup>5</sup>		
▪ Flavor	5.3	16
▪ Sweetness	6.2	16
▪ Texture	4.8	16
▪ Overall	5.4	16

<sup>1</sup> Comments suggested the system was good for garrison training or recreational use, but many questioned its ability to hold up during combat or FTX. Most realized the system was an early prototype and suggested more rugged packets.

<sup>2</sup> More rugged juice container (n=13), smaller mouthpiece (n=14), positive on/off (n=16).

<sup>3</sup> More positive control of water, juice, and off was suggested.

<sup>4</sup> 75% indicated they wanted a package that would work with the entire 100 oz hydration bladder.

<sup>5</sup> Beverage Flavor, Sweetness and Texture:

- They eventually found a "sweet spot" for the concentrate amount they wanted.

- Additional flavors: most listed that they wanted a variety, as any one type would soon get old. Lemonade, tea, and orange were listed. Addition of caffeine to mixture was also mentioned.

Additional Comments:

- 62% thought the OMNDS could improve their performance.
- 87.5% indicated that the drink package would be better stored inside the collapsible bladder holder, and 100% indicated that the placement of the system would depend on the gear they were carrying.
- 56% indicated that the drink was too strong, 19% just right, and 25% too weak.
- When asked about the beverage concentrate pouch, 69% preferred a soft package and 31% preferred a hard package. 3 comments about soft for compression after use, 2 comments on hard for durability. 6 comments on soft with a caveat with respect to making it rugged for military use.
- 88% would prefer a dial (more positive control), and 13% said they would prefer a button IF it has more positive control.
- Comments from Roundtable Discussion:
  - 12 commented on making the bag of concentrate more rugged.
  - 10 commented on reducing the size and weight of the mixing chamber.
  - When asked, all (n=15) wanted a larger bag of concentrate, commensurate with the 100 oz bladder.
  - All (n=15) wanted a much better way to control the selection of OFF/H2O/Mixture with respect to positive control. Also, use with gloves needed to be addressed and considered.
  - Some suggested that the system be able to select various concentrates based on need (i.e., a multiple selector system), but should only be done if system could be made without increase in bulk and weight of current mixing chamber.

## DISCUSSION

The OMNDS was developed to provide a simple means of flavoring water and/or providing nutrients without affecting the sanitation of the water reservoir. To gain feedback from Warfighters regarding the utility of the device, three light infantry-type populations were asked to evaluate initial prototype systems during training. Their opinions were captured by questionnaire and small group discussion. Thus, the system was evaluated by Warfighters performing a broad range of tasks ranging from light to moderate intermittent work to sustained hard work. However, the relatively small sample sizes resulted in outliers having too much influence on the group average score, and several participants appeared to evaluate the whole system (i.e., OMNDS + the hydration system and carrier), both of which may have (negatively) impacted overall acceptability of the OMNDS.

It is noteworthy that the Warfighters' ratings to the specific questions often produced a bimodal or skewed distribution, as some Warfighters rated the system negatively, whereas the majority of Warfighters rated the system more highly. The median score, therefore, often better reflected the group's opinion than the mean score. This was especially true when the Warfighters rated the ease of connecting the drink concentrate pouch onto the system (Figure 5), and when rating the ease of switching between receiving water alone or water + drink concentrate (Figure 6). As such, the median score probably better reflects the acceptability/preference of the Warfighters evaluating the product (see tables for median scores).

In Evaluation 1, the Soldiers rating the OMNDS negatively (<5 on a 9-point scale) were the Soldiers who used the system for the least amount of time. Despite being given individual systems to try for the evaluation, they chose to share a system amongst themselves, and the amount of concentrate used during the evaluation indicates little use of that system. They provided no written comments explaining why they rated the system negatively. Thus, these participants seemed less serious about participation and providing thoughtful, useful feedback. In Evaluation 2, the single Soldier rating the OMNDS negatively didn't appreciate the safety and medical issues created by contaminating their water supply with flavoring and carbohydrate and therefore thought the system was "kind of pointless." These facts suggest that the median score in these instances might also be an underestimate of the "true" score for the system.

## **HARDWARE COMPONENTS**

The Warfighters felt that the drink concentrate bag was "moderately" to "very easy" to attach to the OMNDS. Selecting between water only and water+flavoring was also rated favorably; with mean scores ranging from "somewhat easy" to "moderately easy" and median scores suggesting the majority of Warfighters felt the two button system was "very easy" to operate. Regulator size was scored between "just right" and "somewhat too large." Similarly, regulator weight was scored as "just right" to "somewhat too heavy."

Written comments suggest that the regulator would be improved if it had more positive on-off qualities. A complaint raised regarding the two-button system on the prototype systems was that the push valves were made of too soft material and the flat-end side of the valve was not rugged enough for field use. Tearing of the thin square edge on one side of the button was visually apparent on more than one of the systems evaluated. 88% of Evaluation 3 participants said they would prefer a dial system. The investigative staff also noticed that the push valves became hard to push after cleaning or long idle periods and required lubrication. Future models should investigate other materials/designs that would require less maintenance.

A complaint voiced by Evaluation 3 participants was that the beverage concentrate packets were not sufficiently rugged to use in the field. Leaks either between the juice concentrate and OMNDS or from the valve system occurred during testing to 41%, 40%, and 31% of those participating in Evaluation 1, 2, and 3, respectively. This rather high incidence of leakage documents that improvements are necessary to field-harden the system. However, the incidence of leaks may be biased high, as a single system with a leak in the valve system would have been rated by more than one individual, as only 5 systems were used in any of the evaluations.

65%, 80%, and 69% of those surveyed in Evaluations 1-3, respectively, thought a soft pouch was best. Most thought the OMNDS should be designed with the beverage concentrate pouch stored inside the camelback holder. Modification of the current push-on/pull-off connector to a screw-on or latching system would improve the system, as would a more secure bonding of the soft packet to the connector emitting from the bag.

## BEVERAGE CONCENTRATE

Two beverages were evaluated with the OMNDS. Evaluations 1 & 2 utilized the beverage concentrate derived from the electrolyte beverage evaluation and produced a lemon-flavored electrolyte drink. It was provided in ~50 ml volumes and, when mixed, provided flavoring to ~2 liters of water. Evaluation 3 utilized a lemon-lime flavored drink containing carbohydrate and electrolytes. The ~100 ml volume, when mixed with water, provided the user with ~1 liter of beverage with similar concentration of carbohydrate and electrolytes as commercial sports drinks.

The electrolyte beverage received “like moderately” scores when evaluated without the OMNDS system. Participants in Evaluation 1 and 2, however, rated the beverage as “neither like nor dislike.” The lower ratings during field evaluation may be the result of uncertainty as to what should be rated, as several of the written comments suggest that the OMNDS participants may have scored the concentrate rather than beverage. There was also a wide range of taste preferences within the population surveyed, as sweetness scores ranged from 1 (dislike extremely) to 8 (like very much), and flavor rating ranged from 1 (dislike extremely) to 9 (like extremely).

Warfighters “moderately-liked” the carbohydrate drink produced by the OMNDS. 56% felt the beverage was “too strong,” 19% felt it was “just right,” and 25% felt it was “too weak.” Mean scores for flavor, sweetness, and texture hovered around the “neither like nor dislike.” With regard to sweetness, 50% felt the carbohydrate drink was “too sweet,” whereas 19% felt it wasn’t sweet enough. Taken as a whole, the broad range of taste preferences amongst the participants suggest that future devices should enable the user to self-select the strength of beverage they prefer. Additionally, instructions on how to self-select beverage strength might improve taste scores.

While the drink acceptability scores were disappointing, they are similar to ratings received for commercially available sports drinks (1). In a previous investigation (2) we obtained scores of “like very much” for a maltodextrin-based carbohydrate drink that did not contain electrolytes (ERGO drink; 12% mass/volume, 9% maltodextrin, 2% glucose and 1% fructose), suggesting that different forms of carbohydrate should be considered to improve beverage taste and acceptability of the carbohydrate drink. In terms of preferred flavors, the written comments suggest that a variety of flavors should be provided with the OMNDS. Flavors mentioned in the written comments include lemon, tea, orange, grape, cherry, and strawberry.

## OVERALL ACCEPTABILITY

The results of the three field evaluations suggest OMNDS would be a valuable system for sustaining Warfighter hydration and metabolic status during military operations, but it must be manufactured to withstand the rigors of operational use. The prototype system, which was neither optimized in terms of size nor weight, and was not rugged, received mean value ratings above neutral from all three Warfighter groups. The device also received an overall acceptance score of “like slightly” to “like



moderately.” 73% of Ft. Polk Soldiers surveyed, as well as 62% of Navy Special Operations personnel, felt the OMNDS would improve their performance.

As mentioned above, continued development is needed to improve the size and weight of the regulator, as well as the ergonomics of the system. The beverage concentrate pouch must be made to withstand the rigors of field use. The connection system should be modified to eliminate system leaks. A variety of good tasting flavors, primarily fruit flavors, need to be developed.

Overall, the OMNDS appears to be of value for improving water intake and preventing dehydration. By design, it enables the user to drink flavored drinks without reducing the water reservoir’s resistance to bacterial growth, and the inclusion of carbohydrate without contaminating the water reservoir. It is well documented that flavor variety increases voluntary fluid intake. The OMNDS may also be of value for sustaining Warfighter performance during sustained work. The ingestion of carbohydrate drinks is an established method for sustaining work when meals are likely to be missed or unavailable. The OMNDS capability makes it easy for the user to receive a mixed carbohydrate drink when needed.

## REFERENCES

1. Edwards, J., and J. Zanchi. *Design, Development and Field Evaluation of the Combat Ration Carbohydrate Supplement Pack (Carbopack)*. Natick, MA: U.S. Army Soldier and Biological Chemical Command, Soldier Systems Center. Technical Report TR-03/017L, 2003.
2. Montain, S. J., S. M. McGraw, W. J. Tharion, F. M. Kramer, and R. W. Hoyt. *Acceptability of Carbohydrate Drinks during the Marine Corps Infantry Officer Course 10-Day Field Training Exercise*. Natick, MA: USARIEM. Technical Report T00-2, 1999.
3. Woolfson S., M. Kressy, R. Hoyt, and S. Montain. *Personal Water and Additive Apparatus*. U.S. Patent Application 10/875,020, June 2004.

## **APPENDIX I: QUESTIONNAIRE FOR FIELD EVALUATION 1 AND 2**

ID# \_\_\_\_\_  
 Date \_\_\_\_\_  
 Beverage: OCHO ☐ or juice

## On-The-Move Nutrition Delivery System (OMNDS)

### PRODUCT ACCEPTABILITY

1. Would the OMNDS be a valuable device for field use?

1 <input type="radio"/>	2 <input type="radio"/>	3 <input type="radio"/>	4 <input type="radio"/>	5 <input type="radio"/>	6 <input type="radio"/>	7 <input type="radio"/>	8 <input type="radio"/>	9 <input type="radio"/>
Extremely Unlikely	Very Unlikely	Moderately Unlikely	Somewhat Unlikely	Neither likely or Unlikely	Somewhat Likely	Moderately Likely	Very Likely	Extremely Likely

Comments: \_\_\_\_\_

2. Would you use this item if it were available for your use?

1 <input type="radio"/>	2 <input type="radio"/>	3 <input type="radio"/>	4 <input type="radio"/>	5 <input type="radio"/>	6 <input type="radio"/>	7 <input type="radio"/>	8 <input type="radio"/>	9 <input type="radio"/>
Extremely Unlikely	Very Unlikely	Moderately Unlikely	Somewhat Unlikely	Neither likely or Unlikely	Somewhat Likely	Moderately Likely	Very Likely	Extremely Likely

3. Using the scale below, please rate how likely you would be to use this product during:

	1 Extremely Unlikely	2 Very Unlikely	3 Moderately Unlikely	4 Somewhat Unlikely	5 Neither likely or Unlikely	6 Somewhat Likely	7 Moderately Likely	8 Very Likely	9 Extremely Likely
Garrison training	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Field Training:									
When Field Kitchen is available	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
When MRE is primary food source	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cold Weather Operations	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Hot Weather Operations	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

4. Do you think the OMNDS/beverage could improve your performance?

☐ yes ☐ no

5. Overall, how much do you like or dislike the OMNDS?

1	2	3	4	5	6	7	8	9
Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

### DELIVERY SYSTEM UTILITY

6. Please rate level of difficulty attaching the drink concentrate bag onto the drinking tube.

1	2	3	4	5	6	7	8	9
Extremely Difficult	Very Difficult	Moderately Difficult	Somewhat Difficult	Neither Easy or Difficult	Somewhat Easy	Moderately Easy	Very Easy	Extremely Easy
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

7. Using the scale below, please rate the ease of attaching the drink pouch to the OMNDS.

1	2	3	4	5	6	7	8	9
Extremely Difficult	Very Difficult	Moderately Difficult	Somewhat Difficult	Neither Easy or Difficult	Somewhat Easy	Moderately Easy	Very Easy	Extremely Easy
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

8. Please rate the acceptability of the connection between drink pouch and the OMNDS

1	2	3	4	5	6	7	8	9
Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Did any leaks or dripping occur? ☐ yes ☐ No

If yes, please describe: \_\_\_\_\_

9. Overall, how acceptable was the system for attaching the drink concentrate bag onto the drinking tube and OMNDS?

1	2	3	4	5	6	7	8	9
Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Specific modifications that you would recommend: \_\_\_\_\_

10. Did you use an extension line between drink concentrate bag and the OMNDS?

☐ yes ☐ No

11. Please rate the ease of selecting/switching between receiving water only and receiving the beverage.

- |                            |                            |                            |                            |                              |                            |                            |                            |                            |
|----------------------------|----------------------------|----------------------------|----------------------------|------------------------------|----------------------------|----------------------------|----------------------------|----------------------------|
| 1<br><input type="radio"/> | 2<br><input type="radio"/> | 3<br><input type="radio"/> | 4<br><input type="radio"/> | 5<br><input type="radio"/>   | 6<br><input type="radio"/> | 7<br><input type="radio"/> | 8<br><input type="radio"/> | 9<br><input type="radio"/> |
| Extremely<br>Difficult     | Very<br>Difficult          | Moderately<br>Difficult    | Somewhat<br>Difficult      | Neither Easy<br>or Difficult | Somewhat<br>Easy           | Moderately<br>Easy         | Very Easy                  | Extremely<br>Easy          |

12. How acceptable was the OMNDS regulator size:

- |                            |                            |                            |                            |                            |
|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|
| 1<br><input type="radio"/> | 2<br><input type="radio"/> | 3<br><input type="radio"/> | 4<br><input type="radio"/> | 5<br><input type="radio"/> |
| Much Too<br>Small          | Somewhat<br>Too Small      | Just Right                 | Somewhat<br>Too Large      | Much Too<br>Large          |

13. Please rate the acceptability of the OMNDS regulator weight:

- |                            |                            |                            |                            |                            |
|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|
| 1<br><input type="radio"/> | 2<br><input type="radio"/> | 3<br><input type="radio"/> | 4<br><input type="radio"/> | 5<br><input type="radio"/> |
| Much Too<br>Light          | Somewhat<br>Too Light      | Just Right                 | Somewhat<br>Too Heavy      | Much Too<br>Heavy          |

#### Drink Concentrate Product Packaging

14. Would you prefer the portion size to be:.

- |                            |                            |                            |                            |                              |                            |                            |                            |                            |
|----------------------------|----------------------------|----------------------------|----------------------------|------------------------------|----------------------------|----------------------------|----------------------------|----------------------------|
| 1<br><input type="radio"/> | 2<br><input type="radio"/> | 3<br><input type="radio"/> | 4<br><input type="radio"/> | 5<br><input type="radio"/>   | 6<br><input type="radio"/> | 7<br><input type="radio"/> | 8<br><input type="radio"/> | 9<br><input type="radio"/> |
| Much<br>Smaller            | Quite a Bit<br>Smaller     | Moderately<br>Smaller      | Somewhat<br>Smaller        | Neither Smaller<br>or Larger | Somewhat<br>Larger         | Moderately<br>Larger       | Quite a Bit<br>Larger      | Extremely<br>Larger        |

15. What type of packaging would you prefer for beverage concentrate?

- ☐ Soft Package      ☐ Hard Package

16. Please rate total length of the drink package

- |                            |                            |                            |                            |                            |
|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|
| 1<br><input type="radio"/> | 2<br><input type="radio"/> | 3<br><input type="radio"/> | 4<br><input type="radio"/> | 5<br><input type="radio"/> |
| Much Too<br>Short          | Somewhat<br>Too Short      | Just Right                 | Somewhat<br>Too Long       | Much Too<br>Long           |

### Beverage Acceptability

17. Using the scale below, please rate how much you liked or disliked the following aspects of the flavored beverage

	0 Did Not Eat	1 Dislike Extremely	2 Dislike Very Much	3 Dislike Moderately	4 Dislike Slightly	5 Neither Like nor Dislike	6 Like Slightly	7 Like Moderately	8 Like Very Much	9 Like Extremely
Flavor	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sweetness	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Texture (Mouth Feel)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Overall	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Comments: \_\_\_\_\_

What other flavors would you like? \_\_\_\_\_

### Personal Profile

18. What is your age today? ☐ 19-24 ☐ 25-29 ☐ 30-34 ☐ 35-39 ☐ 40-44 ☐ 45-49

19. During the time period you evaluated the OMNDS, were you:

☐ sedentary ☐ exercising ☐ both

Do you have any suggestions for improving the product?

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